CE 570: Advanced Structural Mechanics

HOMEWORK 7

Part 1: Due ONLINE on blackboard on at 11:30am Saturday, Nov 4, 2017
Part 2: Due ONLINE on blackboard **and** in class at 11:30am Monday, Nov 6, 2017

Part 1 guidelines:

- Work your solution **independently** and **neatly,** on **one side** only on college-rule / engineering paper.
- You may use any combination of mix of **black / blue / green** pens or pencils (but not red).
- Start every problem on a **new** page.
- All **diagrams** must be drawn **neatly** using a straight edge.
- All work should be presented in a **logical sequence**.
- **Scan & submit your homework online** on Blackboard as a **single pdf-file**.
- **Do not email** your homework to the instructor.
- Make sure that your **scan is good quality** and your pdf-file is **clearly readable.** Cell-phone / camera pictures of your homework will **not** be accepted / graded. Illegible or light scans will **not** be graded**.**
- All the scans must be in a **single pdf-file**. To edit, combine or create pdf-files you may use any of the following freely software programs:
    - *PDF Architect* and/or *PDF Creator* (`http://www.pdfforge.org/`)
    - *Primo-pdf* (`http://www.primopdf.com`)

  Try to make sure that your pdf-file size is not more than 5MB (Maximum 10MB).
- The **file name** of your scan must be in the format "`HW??-FirstLast-1.pdf`" where "`??`" is the HW number, "`First`" and "`Last`" are your first and last names, and the "`-1`" denotes Part 1. e.g. `HW01-ArunPrakash-1.pdf`.

Part 2 guidelines: (Work in red pen only)

- The solutions will be posted online at 5pm on Friday (on the due date for Part-1).
- Based on the posted solutions:
    - Correct any errors in your work and revise your solution. If you made any errors, comment why you think you made the error(s) and how you will avoid such error(s) in the future.
    - For each problem, list the most important concepts that you learned.
    - Briefly comment how you may be able to verify / cross-check your revised solution and the posted solution. Also comment, if you think that the posted solution is incorrect.
- You may add pages if necessary, but do **not** submit an entirely new homework file for Part 2.
- **Scan & submit your revised homework online** on Blackboard as a **single pdf-file**.
- The **file name** of your scan must be in the format "`HW??-FirstLast-2.pdf`"

Grading & Solutions:

- **Part 1**: 10 points = 3 problems x 3 points each + 1 presentation point
    - For Part-1, we will grade based only on your effort: You can get full 3 points for a problem, if you made an **honest independent effort** (even if your solution was incorrect!).
- **Part 2**: 5 points (for revisions and comments)
- Total: **15 points**

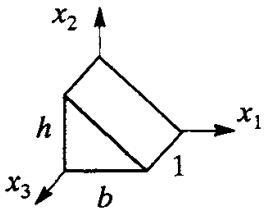
CE 570: Advanced Structural Mechanics

HW Guidelines:

- Read Chapters 3 and 4 from *Fundamentals of Structural Mechanics* by KD Hjelmstad.
- Work your solution neatly, starting all the problems on a new page.
- Be **very precise** with notation. You will lose ½ point for every notational error that you make. So, if you make 10 notational errors in 1 question, you will receive a *zero* score even though your solution may have the right idea.

Problem 1: (5 points)
Solve Problem 94 from the textbook:

94. A triangular prism of material (with base b, height h, and unit thickness) has an internal stress given by the stress field

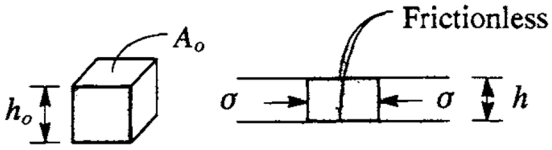


$$\mathbf{S}(\mathbf{x}) = \frac{\varrho}{bh}(x_1 - h)(bx_2 + hx_1 - bh)[\mathbf{e}_2 \otimes \mathbf{e}_2]$$

where ϱ is the (constant) unit weight of the material and $\mathbf{e}_i$ is the unit base vector in the direction of the coordinate axis x_i. Find the body force $\mathbf{b}$ required for equilibrium. Find the tractions of all of the faces of the prism. Sketch the normal (σ) and tangential (τ) components of traction on the three faces whose normals are orthogonal to the $\mathbf{e}_3$ direction.

Problem 2: (5 points)
Solve Problem 111 from the textbook:

111. A block of elastic material, having Lamé constants $\lambda = 1000$ psi and $\mu = 1000$ psi is subjected to a lateral compressive pressure of $\sigma = 80$ psi and clamped between two frictionless rigid plates that reduce the height of the block to 99% of its original height. Compute the total force required on the plates to accomplish the motion. Compute the volume of the block after deformation. Compute the change in the area of the block on the faces in contact with the plates.



Problem 3: (5 points)
Solve Problem 115 from the textbook:

115. The strain energy function of a nonlinear hyperelastic material is given by

$$W(\mathbf{E}) = aE_{ii}\ln(1 + E_{jj}) + \frac{3}{2}bE_{ij}E_{ij}$$

where ln(.) indicates the natural logarithm of (.), a and b are known material constants, and $\mathbf{E} = E_{ij}[\mathbf{e}_i \otimes \mathbf{e}_j]$ is the strain tensor. Find the stress tensor $\mathbf{S}$ as a function of the strain $\mathbf{E}$ implied by the strain energy function. Consider a hydrostatic state of stress with pressure p in which the stress tensor is given by $\mathbf{S} = p\mathbf{I}$. Set up a relationship between the change in volume and the pressure p. What is the pressure required to decrease the volume to 95% of the original volume (assume that the linearized strain tensor is adequate)?